

WHAT IS THE DENSITY OF A 2.5-CM³ GLASSMARBLE THAT HAS A MASS OF 7.5 G?

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UNDERSTANDING THE DENSITY OF MATERIALS IS FUNDAMENTAL IN VARIOUS FIELDS SUCH AS PHYSICS, CHEMISTRY, ENGINEERING, AND EVERYDAY LIFE. IN THIS ARTICLE, WE WILL EXPLORE HOW TO CALCULATE THE DENSITY OF A SPECIFIC GLASSMARBLE, EXAMINE WHAT DENSITY MEANS, AND DISCUSS ITS SIGNIFICANCE. SPECIFICALLY, WE WILL ANALYZE A GLASSMARBLE WITH A VOLUME OF 2.5 CUBIC CENTIMETERS (CM³) AND A MASS OF 7.5 GRAMS (G), PROVIDING A COMPREHENSIVE GUIDE TO UNDERSTANDING THE CONCEPT OF DENSITY THROUGH THIS EXAMPLE.

WHAT IS DENSITY?

DEFINITION OF DENSITY

DENSITY IS A PHYSICAL PROPERTY THAT MEASURES HOW MUCH MASS IS CONTAINED WITHIN A GIVEN VOLUME OF A SUBSTANCE. IT IS EXPRESSED MATHEMATICALLY AS:

$$\rho = \frac{m}{V}$$

WHERE:

- ρ IS THE DENSITY,
- m IS THE MASS OF THE OBJECT,
- V IS THE VOLUME OF THE OBJECT.

THE SI UNIT OF DENSITY IS KILOGRAMS PER CUBIC METER (KG/M³), BUT IN PRACTICAL APPLICATIONS, ESPECIALLY WITH SMALL OBJECTS LIKE GLASSMARBLES, GRAMS PER CUBIC CENTIMETER (G/CM³) OR GRAMS PER MILLILITER (G/ML) ARE COMMONLY USED.

SIGNIFICANCE OF DENSITY

DENSITY HELPS DETERMINE:

- WHETHER AN OBJECT WILL FLOAT OR SINK IN A FLUID,
- MATERIAL IDENTIFICATION AND QUALITY CONTROL,
- DESIGN CONSIDERATIONS IN MANUFACTURING,
- HOW OBJECTS INTERACT WITH THEIR ENVIRONMENT.

FOR EXAMPLE, MATERIALS WITH HIGHER DENSITIES TEND TO BE HEAVIER FOR THE SAME VOLUME, AFFECTING THEIR BEHAVIOR IN DIFFERENT CONTEXTS.

CALCULATING THE DENSITY OF THE GLASSMARBLE

GIVEN DATA

LET'S REVISIT THE SPECIFIC PROBLEM:

- VOLUME OF THE GLASSMARBLE, $V = 2.5 \text{ CM}^3$
- MASS OF THE GLASSMARBLE, $m = 7.5 \text{ G}$

USING THE FUNDAMENTAL DENSITY FORMULA:

$$\rho = \frac{m}{V}$$

WE CAN SUBSTITUTE THE GIVEN VALUES:

$$\rho = \frac{7.5 \text{ g}}{2.5 \text{ cm}^3}$$

CALCULATING THE DENSITY

PERFORM THE DIVISION:

$$\rho = 3 \text{ g/cm}^3$$

THUS, THE DENSITY OF THE GLASSMARBLE IS 3 GRAMS PER CUBIC CENTIMETER (g/cm^3).

INTERPRETING THE RESULT

WHAT DOES A DENSITY OF 3 g/cm^3 MEAN?

A DENSITY OF 3 g/cm^3 INDICATES THAT EACH CUBIC CENTIMETER OF THE GLASSMARBLE WEIGHS 3 GRAMS. THIS VALUE IS SPECIFIC TO THE MATERIAL'S COMPOSITION AND STRUCTURE, TYPICAL FOR CERTAIN TYPES OF GLASS.

COMPARISON WITH OTHER MATERIALS

TO CONTEXTUALIZE THIS VALUE, CONSIDER THE DENSITIES OF COMMON MATERIALS:

MATERIAL	DENSITY (g/cm^3)	NOTES
WATER	1.00	STANDARD REFERENCE POINT
GLASS (AVERAGE)	2.4 - 2.8	VARIES DEPENDING ON COMPOSITION
LEAD	11.34	VERY DENSE METAL
ALUMINUM	2.70	LIGHTWEIGHT METAL
WOOD (AVERAGE)	0.6 - 0.9	LESS DENSE THAN GLASS

GIVEN THAT THE DENSITY OF THE GLASSMARBLE IS APPROXIMATELY 3 g/cm^3 , IT IS DENSER THAN AVERAGE GLASS, WHICH SUGGESTS A SPECIFIC COMPOSITION OR MANUFACTURING PROCESS THAT RESULTS IN A SLIGHTLY HIGHER DENSITY.

FACTORS AFFECTING THE DENSITY OF GLASSMARBLES

MATERIAL COMPOSITION

GLASSMARBLES ARE TYPICALLY MADE FROM SILICA (SAND), SODA ASH, AND LIME. VARIATIONS IN THESE COMPONENTS OR THE ADDITION OF OTHER ELEMENTS (LIKE BORON OR LEAD) CAN INFLUENCE DENSITY.

MANUFACTURING PROCESS

- COOLING RATE: RAPID COOLING CAN PRODUCE DIFFERENT INTERNAL STRUCTURES AFFECTING DENSITY.
- IMPURITIES: THE PRESENCE OF IMPURITIES OR TRAPPED AIR BUBBLES CAN ALTER THE OVERALL DENSITY.

STRUCTURAL FACTORS

- POROSITY: MORE POROUS GLASSMARBLES TEND TO HAVE LOWER DENSITY.
- CRYSTALLINITY: THE DEGREE OF CRYSTALLINITY CAN INFLUENCE DENSITY, WITH MORE CRYSTALLINE STRUCTURES OFTEN BEING DENSER.

APPLICATIONS AND IMPORTANCE OF KNOWING DENSITY

MATERIAL IDENTIFICATION

KNOWING THE DENSITY HELPS IDENTIFY THE MATERIAL COMPOSITION OF A GLASSMARBLE, WHICH CAN BE ESSENTIAL FOR QUALITY CONTROL OR RECREATING SIMILAR PRODUCTS.

DESIGN AND ENGINEERING

ENGINEERS CAN USE DENSITY DATA TO DETERMINE HOW A GLASSMARBLE WILL BEHAVE IN DIFFERENT ENVIRONMENTS, SUCH AS IN WATER OR OTHER LIQUIDS, INFLUENCING ITS BUOYANCY.

EDUCATIONAL PURPOSES

CALCULATING AND UNDERSTANDING DENSITY PROVIDES A PRACTICAL EXAMPLE OF FUNDAMENTAL PHYSICS CONCEPTS, HELPING STUDENTS LEARN HOW TO APPLY MATHEMATICAL FORMULAS TO REAL-WORLD OBJECTS.

ADDITIONAL CONSIDERATIONS IN DENSITY CALCULATIONS

UNITS AND CONVERSIONS

- ALWAYS ENSURE THE UNITS FOR MASS AND VOLUME ARE COMPATIBLE.
- CONVERT UNITS IF NECESSARY, FOR EXAMPLE, FROM GRAMS TO KILOGRAMS OR CUBIC CENTIMETERS TO CUBIC METERS, DEPENDING ON THE CONTEXT.

SIGNIFICANT FIGURES

- MAINTAIN APPROPRIATE SIGNIFICANT FIGURES BASED ON THE PRECISION OF THE GIVEN DATA. IN THIS CASE, THE DENSITY IS REPORTED AS 3 g/cm^3 , ROUNDED TO TWO SIGNIFICANT FIGURES.

DENSITY IN DIFFERENT CONTEXTS

- FOR LIQUIDS, DENSITY IS OFTEN EXPRESSED IN g/mL .
- FOR GASES, DENSITIES ARE MUCH LOWER AND USUALLY EXPRESSED IN g/L OR MOLAR DENSITIES.

CONCLUSION

CALCULATING THE DENSITY OF A GLASSMARBLE WITH A VOLUME OF 2.5 cm^3 AND A MASS OF 7.5 g YIELDS A VALUE OF 3 g/cm^3 . UNDERSTANDING THIS PROPERTY ALLOWS US TO INFER THE MATERIAL'S INTERNAL STRUCTURE, COMPARE IT WITH OTHER

SUBSTANCES, AND PREDICT ITS BEHAVIOR IN VARIOUS ENVIRONMENTS. WHETHER FOR SCIENTIFIC RESEARCH, MANUFACTURING, OR EDUCATIONAL PURPOSES, MASTERING THE CONCEPT OF DENSITY IS ESSENTIAL FOR ANALYZING AND WORKING WITH DIFFERENT MATERIALS EFFECTIVELY.

SUMMARY:

- DENSITY FORMULA: $\rho = \frac{m}{V}$
- CALCULATED DENSITY: 3 g/cm^3
- SIGNIFICANCE: MATERIAL IDENTIFICATION, BUOYANCY, QUALITY CONTROL
- INFLUENCING FACTORS: COMPOSITION, MANUFACTURING PROCESS, STRUCTURAL FEATURES

BY UNDERSTANDING HOW TO DETERMINE AND INTERPRET DENSITY, YOU CAN BETTER APPRECIATE THE PROPERTIES OF EVERYDAY OBJECTS LIKE GLASS MARBLES AND THEIR APPLICATIONS IN THE REAL WORLD.

FREQUENTLY ASKED QUESTIONS

WHAT IS THE FORMULA TO CALCULATE THE DENSITY OF A GLASS MARBLE?

DENSITY IS CALCULATED BY DIVIDING THE MASS OF THE OBJECT BY ITS VOLUME, USING THE FORMULA: $\text{Density} = \text{Mass} / \text{Volume}$.

HOW DO YOU FIND THE DENSITY OF A GLASS MARBLE WITH A MASS OF 7.5 G AND A VOLUME OF 2.5 cm^3 ?

YOU DIVIDE THE MASS (7.5 g) BY THE VOLUME (2.5 cm^3): $\text{Density} = 7.5 \text{ g} / 2.5 \text{ cm}^3 = 3 \text{ g/cm}^3$.

WHAT IS THE SIGNIFICANCE OF KNOWING THE DENSITY OF A GLASS MARBLE?

KNOWING THE DENSITY HELPS DETERMINE THE MATERIAL PROPERTIES AND WHETHER THE MARBLE IS MADE OF GLASS OR ANOTHER SUBSTANCE, AND CAN ALSO BE USEFUL IN IDENTIFYING ITS PURITY OR COMPOSITION.

IS THE CALCULATED DENSITY OF THE GLASS MARBLE TYPICAL FOR GLASS MATERIALS?

YES, A DENSITY OF AROUND 2.5 TO 3 g/cm^3 IS TYPICAL FOR GLASS MATERIALS, SO 3 g/cm^3 FALLS WITHIN THE EXPECTED RANGE.

HOW DOES THE VOLUME OF 2.5 cm^3 RELATE TO THE MARBLE'S SIZE?

A VOLUME OF 2.5 cm^3 INDICATES THE MARBLE IS QUITE SMALL, ROUGHLY ABOUT THE SIZE OF A SMALL MARBLE OR A LARGE PEA.

CAN THE DENSITY VALUE HELP IN DETERMINING IF THE MARBLE IS SOLID OR HOLLOW?

YES, A DENSITY SIGNIFICANTLY LOWER THAN TYPICAL GLASS DENSITIES MIGHT SUGGEST THE MARBLE IS HOLLOW OR CONTAINS AIR POCKETS, BUT IN THIS CASE, THE DENSITY ALIGNS WITH SOLID GLASS.

WHAT UNITS ARE USED IN THE CALCULATION OF THE MARBLE'S DENSITY?

THE MASS IS IN GRAMS (g), AND THE VOLUME IS IN CUBIC CENTIMETERS (cm^3), SO THE DENSITY IS EXPRESSED IN GRAMS PER CUBIC CENTIMETER (g/cm^3).

IF THE MASS OF THE MARBLE INCREASED TO 10 G BUT VOLUME REMAINED THE SAME, WHAT WOULD BE ITS NEW DENSITY?

THE NEW DENSITY WOULD BE $10 \text{ g} / 2.5 \text{ cm}^3 = 4 \text{ g/cm}^3$.

ADDITIONAL RESOURCES

WHAT IS THE DENSITY OF A 2.5- cm^3 GLASS MARBLE THAT HAS A MASS OF 7.5 G?

UNDERSTANDING THE PROPERTIES OF EVERYDAY OBJECTS CAN OFTEN SEEM STRAIGHTFORWARD, YET IT OPENS THE DOOR TO FASCINATING SCIENTIFIC PRINCIPLES. ONE SUCH INQUIRY INVOLVES CALCULATING THE DENSITY OF A SMALL GLASS MARBLE—A QUESTION THAT, AT FIRST GLANCE, APPEARS SIMPLE BUT REVEALS DEEPER INSIGHTS INTO MATERIAL SCIENCE AND PHYSICS UPON CLOSER EXAMINATION. SPECIFICALLY, WHAT IS THE DENSITY OF A GLASS MARBLE MEASURING 2.5 CUBIC CENTIMETERS (cm^3) WITH A MASS OF 7.5 GRAMS (G)? UNRAVELING THIS QUESTION INVOLVES EXPLORING FUNDAMENTAL CONCEPTS SUCH AS VOLUME, MASS, AND DENSITY, AS WELL AS PRACTICAL APPLICATIONS IN VARIOUS SCIENTIFIC AND INDUSTRIAL CONTEXTS. LET'S EMBARK ON A DETAILED JOURNEY TO UNDERSTAND HOW TO DETERMINE THE DENSITY OF THIS GLASS MARBLE, WHY IT MATTERS, AND WHAT IT REVEALS ABOUT THE MATERIAL PROPERTIES OF GLASS.

UNDERSTANDING DENSITY: THE FUNDAMENTAL CONCEPT

BEFORE DIVING INTO SPECIFIC CALCULATIONS, IT'S ESSENTIAL TO GRASP WHAT DENSITY TRULY MEANS IN SCIENTIFIC TERMS. DENSITY IS A MEASURE OF HOW MUCH MASS IS CONTAINED WITHIN A GIVEN VOLUME OF A SUBSTANCE. IT PROVIDES INSIGHT INTO THE COMPACTNESS OR CONCENTRATION OF MATTER IN AN OBJECT, WHICH CAN INFLUENCE ITS PHYSICAL CHARACTERISTICS LIKE BUOYANCY, STRENGTH, AND THERMAL PROPERTIES.

DEFINITION OF DENSITY

- MATHEMATICALLY, DENSITY (ρ) IS EXPRESSED AS:

$$\rho = \text{MASS} / \text{VOLUME}$$

- THE UNITS OF DENSITY DEPEND ON THE UNITS USED FOR MASS AND VOLUME. COMMON UNITS INCLUDE GRAMS PER CUBIC CENTIMETER (g/cm^3), KILOGRAMS PER CUBIC METER (kg/m^3), AND POUNDS PER CUBIC FOOT (lb/ft^3).

WHY DENSITY MATTERS

- MATERIAL IDENTIFICATION: DIFFERENT MATERIALS HAVE CHARACTERISTIC DENSITIES, ALLOWING SCIENTISTS AND ENGINEERS TO IDENTIFY SUBSTANCES OR VERIFY MATERIAL PURITY.
- BUOYANCY AND ARCHIMEDES' PRINCIPLE: KNOWING DENSITY HELPS DETERMINE WHETHER AN OBJECT WILL FLOAT OR SINK IN A PARTICULAR FLUID.
- ENGINEERING AND MANUFACTURING: DENSITY INFLUENCES MATERIAL SELECTION FOR PRODUCTS, AFFECTING STRENGTH, WEIGHT, AND DURABILITY.

WITH THESE FOUNDATIONAL IDEAS IN MIND, LET'S PROCEED TO ANALYZE THE SPECIFIC CASE OF THE GLASS MARBLE.

GATHERING THE DATA: MASS AND VOLUME

THE PROBLEM PROVIDES TWO KEY PIECES OF INFORMATION:

- VOLUME OF THE MARBLE (V): 2.5 cm^3
- MASS OF THE MARBLE (m): 7.5 g

THESE MEASUREMENTS ARE TYPICALLY OBTAINED THROUGH EXPERIMENTAL METHODS:

- VOLUME MEASUREMENT: OFTEN INVOLVES GEOMETRIC CALCULATIONS IF THE SHAPE IS REGULAR. FOR A SPHERE, THE VOLUME CAN BE CALCULATED FROM THE RADIUS.
- MASS MEASUREMENT: USUALLY DETERMINED USING A PRECISE SCALE OR BALANCE.

IN THIS SCENARIO, THE VOLUME AND MASS ARE KNOWN, SO THE CALCULATION OF DENSITY BECOMES STRAIGHTFORWARD.

CALCULATING THE DENSITY

APPLYING THE DENSITY FORMULA:

$$\rho = m / V$$

SUBSTITUTING THE KNOWN VALUES:

$$\rho = 7.5 \text{ g} / 2.5 \text{ cm}^3$$

PERFORMING THE DIVISION:

$$\rho = 3 \text{ g/cm}^3$$

THIS RESULT INDICATES THAT THE DENSITY OF THE GLASS MARBLE IS 3 GRAMS PER CUBIC CENTIMETER.

INTERPRETING THE RESULT

- A DENSITY OF 3 g/cm³ SUGGESTS THAT THE MARBLE IS RELATIVELY DENSE, CONSISTENT WITH TYPICAL GLASS DENSITIES, WHICH USUALLY RANGE FROM ABOUT 2.4 TO 2.8 g/cm³.
- THE SLIGHT DIFFERENCE MIGHT BE DUE TO VARIATIONS IN GLASS COMPOSITION OR MEASUREMENT UNCERTAINTIES.

UNDERSTANDING THE MATERIAL: IS THE MARBLE TYPICAL GLASS?

HAVING CALCULATED THE DENSITY, IT'S HELPFUL TO COMPARE IT WITH KNOWN STANDARD VALUES FOR GLASS:

MATERIAL TYPE	TYPICAL DENSITY (g/cm ³)
Borosilicate Glass	2.23 – 2.32
Soda-Lime Glass	2.4 – 2.5
Lead Glass	3.1 – 4.0

THE CALCULATED DENSITY OF 3 g/cm³ IS SLIGHTLY HIGHER THAN TYPICAL SODA-LIME GLASS, INDICATING THE MARBLE MAY CONTAIN ADDITIONAL ELEMENTS SUCH AS LEAD, OR IT MIGHT BE MADE FROM A DIFFERENT GLASS FORMULATION. THIS HIGHLIGHTS HOW DENSITY CAN SERVE AS A FINGERPRINT FOR MATERIAL COMPOSITION.

IMPLICATIONS OF DENSITY VARIATIONS

- SLIGHT DEVIATIONS CAN BE DUE TO IMPURITIES OR MANUFACTURING PROCESSES.
- HIGHER DENSITY MATERIALS TEND TO BE HEAVIER AND MAY HAVE DIFFERENT OPTICAL OR MECHANICAL PROPERTIES.

PRACTICAL APPLICATIONS AND SIGNIFICANCE

UNDERSTANDING AND CALCULATING DENSITY ISN'T MERELY AN ACADEMIC EXERCISE—IT HAS PRACTICAL IMPLICATIONS ACROSS

VARIOUS FIELDS:

MATERIAL IDENTIFICATION AND QUALITY CONTROL

MANUFACTURERS OFTEN VERIFY THE DENSITY OF THEIR GLASS PRODUCTS TO ENSURE CONSISTENCY AND QUALITY. ANOMALIES IN DENSITY CAN INDICATE IMPURITIES, DEFECTS, OR INCORRECT FORMULATIONS.

SCIENTIFIC RESEARCH AND MATERIAL SCIENCE

RESEARCHERS ANALYZE THE DENSITY OF MATERIALS TO UNDERSTAND THEIR STRUCTURE, BONDING, AND BEHAVIOR UNDER DIFFERENT CONDITIONS. FOR EXAMPLE, IN THE STUDY OF GLASS DURABILITY OR OPTICAL PROPERTIES, DENSITY PLAYS A KEY ROLE.

INDUSTRY AND CONSUMER PRODUCTS

IN THE TOY INDUSTRY, THE WEIGHT AND DENSITY OF MARBLES INFLUENCE THEIR PLAYABILITY, SAFETY, AND MANUFACTURING STANDARDS. KNOWING THE DENSITY HELPS IN DESIGNING MARBLES WITH DESIRED PROPERTIES.

ENVIRONMENTAL AND BUOYANCY STUDIES

DENSITY CALCULATIONS ARE ESSENTIAL IN UNDERSTANDING HOW OBJECTS INTERACT WITH FLUIDS, AFFECTING EVERYTHING FROM UNDERWATER NAVIGATION TO THE DESIGN OF BUOYANT DEVICES.

BEYOND THE BASICS: FACTORS AFFECTING DENSITY CALCULATIONS

WHILE THE CALCULATION APPEARS STRAIGHTFORWARD, REAL-WORLD SCENARIOS OFTEN INVOLVE COMPLEXITIES:

- TEMPERATURE EFFECTS: MATERIALS EXPAND OR CONTRACT WITH TEMPERATURE CHANGES, AFFECTING VOLUME AND THUS DENSITY.
- MEASUREMENT ACCURACY: PRECISE MEASUREMENT OF MASS AND VOLUME IS CRUCIAL, ESPECIALLY FOR SMALL OBJECTS LIKE MARBLES.
- SHAPE AND POROSITY: IRREGULAR SHAPES OR INTERNAL POROSITY CAN INFLUENCE ACTUAL DENSITY, MAKING THE THEORETICAL CALCULATION AN APPROXIMATION.

ADVANCED CONSIDERATIONS

- TO REFINE THE DENSITY MEASUREMENT, TECHNIQUES SUCH AS ARCHIMEDES' PRINCIPLE CAN BE EMPLOYED, WHERE THE VOLUME IS DETERMINED BY WATER DISPLACEMENT.
- FOR IRREGULAR OR POROUS OBJECTS, METHODS LIKE HELIUM PYCNOMETRY PROVIDE MORE ACCURATE DENSITY MEASUREMENTS.

CONCLUSION: THE SIGNIFICANCE OF THE DENSITY CALCULATION

IN CONCLUSION, THE DENSITY OF A 2.5- cm^3 GLASS MARBLE WITH A MASS OF 7.5 GRAMS IS APPROXIMATELY 3 g/cm^3 . THIS CALCULATION, WHILE SIMPLE IN FORM, OPENS UP A WINDOW INTO UNDERSTANDING MATERIAL PROPERTIES, MANUFACTURING QUALITY, AND SCIENTIFIC PRINCIPLES. RECOGNIZING THE DENSITY VALUE HELPS IDENTIFY THE TYPE OF GLASS, ASSESS ITS QUALITY, AND EXPLORE ITS BEHAVIOR IN DIFFERENT ENVIRONMENTS.

FROM EVERYDAY TOYS TO ADVANCED SCIENTIFIC RESEARCH, THE CONCEPT OF DENSITY REMAINS A FUNDAMENTAL PILLAR IN UNDERSTANDING THE PHYSICAL WORLD. WHETHER FOR EDUCATIONAL PURPOSES, INDUSTRY STANDARDS, OR SCIENTIFIC EXPLORATION, KNOWING HOW TO DETERMINE AND INTERPRET DENSITY IS A VITAL SKILL THAT BRIDGES THEORETICAL KNOWLEDGE AND PRACTICAL APPLICATION. AS WE CONTINUE TO EXPLORE THE MATERIALS THAT SHAPE OUR WORLD, THE HUMBLE GLASS MARBLE PROVIDES A SMALL YET INSIGHTFUL EXAMPLE OF THE IMPORTANCE OF PRECISE MEASUREMENT AND SCIENTIFIC ANALYSIS IN UNRAVELING THE PROPERTIES OF MATTER.

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